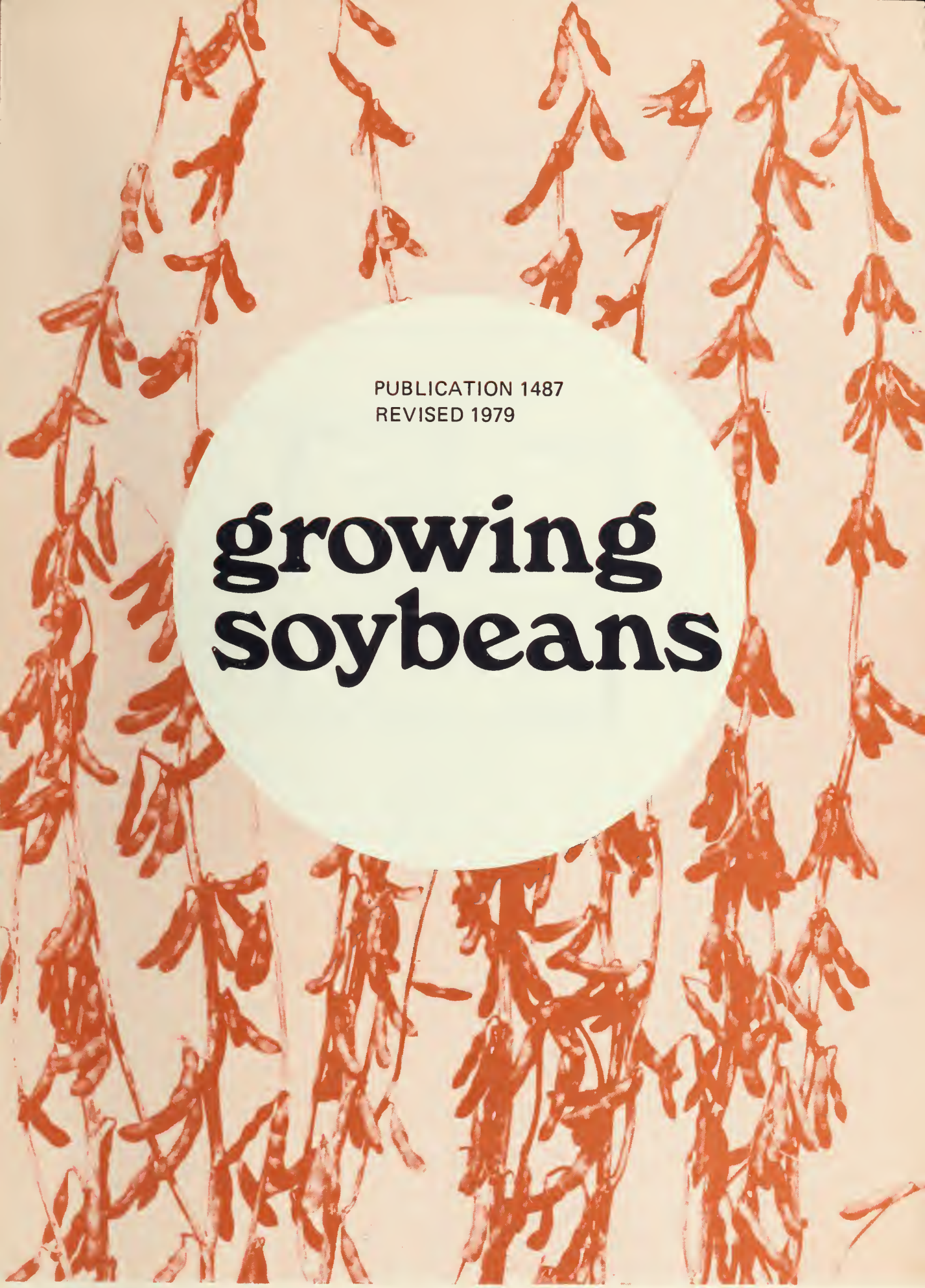

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growing soybeans

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growing soybeans

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INTRODUCTION

Soybeans, *Glycine max* (L.) Merr., were introduced into Canada as a forage crop. Now they are grown as an oil-protein seed crop, which contains about 20% oil and 40% protein on a dry-weight basis. Soybean seed is processed for edible oil; feed containing 44-50% protein is made from the remaining meal. Some soybeans are exported for use in specialty foods. On some farms, whole soybeans are used as a protein supplement, but the preparation and use of this feed depend on the type of animal being fed.

The soybean crop is important in Canada. Over the 35-year period from 1942 to 1976, soybean hectareage increased 10-fold from 17 000 ha during 1942-46 to 170 000 ha during 1972-76. Nearly all this hectareage has been in Ontario. The total farm value increased from $1.6 million to $66.2 million during these 35 years. The average yield increased 62% (from 1250 to 2030 kg/ha). Because of its importance the soybean may become established as a crop in other provinces.

Research in several fields has contributed to the increase in soybean hectareage and yield. Plant breeders have been continually improving the yield and maturity of varieties. Better fertilizer practices have increased the yields. Improvements in farm machinery have increased the number of hectares a grower can handle. Effective, economic herbicides are now available, greatly reducing the need for interrow cultivation. As production methods continue to improve, and because our soybean production meets less than half our domestic needs, the soybean hectareage should continue to increase.

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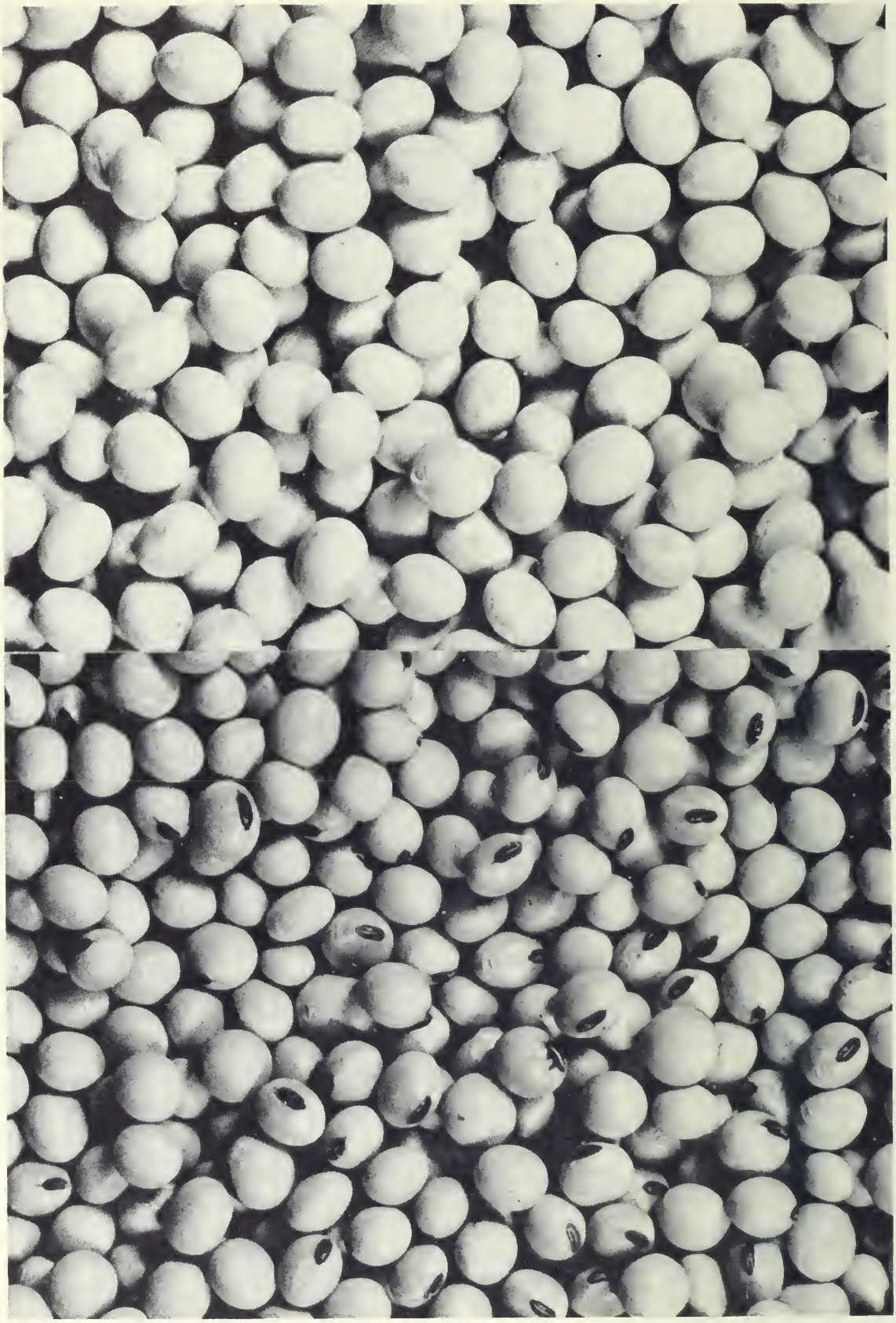

Fig. 1. Soybeans are round and, depending on the variety, are commonly 6–8 mm in diameter; the hila (seed scar) may be brown, black, gray, or yellow.

Fig. 2 *Top,* soybean pods are formed at leaf nodes from the bottom to the top of the plant; *Bottom,* at maturity the leaves are shed and the pods turn brown.

SELECTING A VARIETY

Many varieties of soybeans are sold in Canada, but only a few may be suitable for a particular region. New, improved varieties are being developed continually and tests conducted at many locations across Canada provide information about them. In areas where the soybean is an established crop, recommendations are published annually and are available on request from either the provincial or federal departments of agriculture. In areas where soybeans are being tried as a new crop, information is available from the research stations.

Maturity, yield, disease resistance, and lodging resistance are the most important characteristics to consider in soybeans. Choose a variety that is early enough to be near maturity before the first frost in the fall. After the leaves have started to drop, the quality and yield are not affected by the first frost, which is usually light. However, frozen, immature beans are small, of inferior quality, and yield less than mature beans. On the other hand, a variety that is too early for an area usually yields less because it does not make full use of the growing season. When fall-planted wheat is to follow the soybean crop, select a variety that matures early enough to permit timely planting of wheat.

Select a variety, if one is available in your local recommendations, that is tolerant or resistant to the prevalent diseases in your area, such as phytophthora rot on clay soils.

Lodging resistance is important because lodged plants are more difficult to combine and some seed may be lost in harvesting. Severe midseason lodging reduces seed development.

No variety excels in all the desired characteristics; therefore you will have to use your judgment. If you are planning to start growing soybeans, choose a couple of varieties on the basis of test information and grow them to find out which is the better one for you. If you grow soybeans regularly and have established preferences, keep them under review because improved varieties are released periodically.

SOYBEANS IN A ROTATION

Soybeans can be grown successfully at any place in a rotation if the soil fertility is adequate. They do very well after corn, but should not be planted in fields that have received excessive amounts of atrazine. Planting of soybeans for more than 3 consecutive years and continuous rotation of soybeans with other legumes are not advisable because of a buildup of the organism that causes brown stem rot.

Do not plant soybeans on summerfallowed fields because high levels of nitrogen (greater than 30 kg/ha) will delay maturity. Soybeans may be used as a substitute crop in place of fallowing.

SOILS AND FERTILIZERS

Soybeans grow well on a fairly wide range of soils, but do best on well-drained, deep, fertile loams. Good drainage is important on fine-textured soils such as clay

loams and clays. If the natural drainage is poor, install a system of tile or surface drains. Fertile sandy soils produce good crops when the rainfall is well distributed.

Soybeans need a high level of fertility to produce a good yield. A soybean crop of 3000 kg/ha requires about 25 kg of phosphorus, 105 kg of potassium, and 295 kg of nitrogen. It also uses appreciable amounts of calcium, magnesium, sulfur, manganese, and other elements. At harvest, about 60% of the phosphorus, and about 75% of the potassium and nitrogen are contained in the soybean seed.

The amount and analysis of the fertilizer that should be used depend on the fertility of the soil and the fertilizer applied for the previous crop. The best way to determine the amount and analysis of the correct fertilizer you need is to have your soil tested. If this is not done it is most important that you follow the general recommendations of your provincial fertilizer board or local research station, because there are local and regional differences in soil fertility. Usually, the addition of only a small amount of nitrogen is recommended because it is obtained from nodulation. Varying amounts of phosphorus and potassium may be needed. In some cases magnesium or sulfur may also be required.

Fertilizer for a soybean crop may be broadcast and worked into the soil by plowing, disking, or cultivating. Alternatively, a planter with a separate shoe for fertilizer placement may be used to put the fertilizer 5 cm to the side and 5 cm below the seed. Since soybean seedlings are easily damaged by direct contact with a fertilizer, do not use split-boot applicators. Also, when large quantities of fertilizer per hectare are needed, it is advisable to apply only a part of it in the band.

Manganese deficiency may occur in soybeans, especially in southwestern Ontario. The upper leaves of affected plants vary from pale green (slight deficiency) to yellow (severe deficiency) but the veins remain green. Small brown spots may also appear, especially on older leaves. Correct the deficiency as soon as it is detected by spraying with either 2 kg manganese from manganese sulfate, or 0.2 kg manganese in chelated form, dissolved in 200 L or more of water per hectare. Use a "spreader sticker" in the spray. If the deficiency is severe, a second spray may be beneficial. On fields deficient in manganese, each soybean crop may be sprayed as a regular practice.

A soil pH of 6.0–6.5 (slightly acid) to 7.5 (slightly alkaline) is desirable for growing soybeans on most mineral soils. Apply lime according to soil-test recommendations. Calcitic lime contains calcium, and dolomitic lime contains calcium and magnesium, which are both necessary for good soybean production.

Avoid the saline soils that occur in the Prairie Provinces. In some areas these soils are referred to as alkali. Soybeans have a lower tolerance for salty soils than other crops such as rapeseed.

The most profitable approach to fertilizing soybeans is to apply fertilizer and lime according to the rotation, the fertility and pH of the soil as determined by soil tests, and your yield records. Do not deplete the soil of nutrients; however, avoid applying unneeded fertilizer. Remember that all the fertilizer applied in a given year is not used by the crop, partly because the roots do not contact it. When producing high yields, each crop depends somewhat on good inherent and residual fertility.

PREPARING THE SEEDBED

A firm seedbed of good tilth is very important. It holds the moisture near the surface so that the soybeans may be planted in the upper 2.5–5 cm of soil. At this depth, with enough moisture, the seeds germinate quickly and evenly.

Fall tillage

For heavy soils or sod on light soils fall plowing is usually best, except that in the Prairie Provinces plowing is not recommended because of the risk of soil erosion. Fall tillage to partially incorporate the crop residue may be done with a chisel type cultivator; if carried out early, many weeds will grow but will later be killed by frost. Incorporating the residue from the previous crop adds organic matter and improves the texture of the soil.

Fall tillage of clay soils is better than spring tillage because freezing–thawing action improves soil tilth and conserves soil moisture, which results in higher yields and earlier maturity of the soybean crop. Also, less land preparation is required at planting time.

Spring tillage

Light, sandy soils are usually plowed in the spring as soon as the land is dry enough. It is best to pull a packer behind the plow or disk, particularly if there is a heavy straw cover on the field. Spring plowing of heavy soils often results in a loose, lumpy seedbed that dries out too quickly.

Disking and harrowing, or field-cultivating, complete the preparation of the seedbed. If the land was tilled in the fall, delay all spring tillage until just before planting. This conserves moisture and provides a more mellow seedbed. Till only enough to obtain the desired seedbed.

PLANTING THE CROP

Seed treatment

Treated seed survives poor germinating conditions much better than untreated seed. If the temperature of the soil is cool, or the soil is extremely dry, make sure that the seed is treated with a suitable fungicide before planting. Seed dealers may treat their seed with a fungicide before bagging it for sale. Some dealers do custom seed treatments. If you treat your own seed, follow the fungicide manufacturer's directions carefully. To prevent loss of plants to seed maggots and wireworms, apply suitable insecticides. These can be applied during the 2 months before planting only if a fungicide is applied at the same time. Otherwise a planter-box formulation of dry insecticides can be used to treat the seed when planting and the fungicide can be applied at any time between harvesting and planting. For your protection while mixing, use rubber gloves and a wooden paddle and avoid breathing the dust.

Inoculation

The presence of certain bacteria (*Rhizobia*) causes the formation of nodules on growing soybean roots. The bacteria live in these nodules on food provided by the soybean plant. In return they convert nitrogen from the air into a form the plant can use. Successful nodulation greatly reduces the nitrogen fertilizer requirements of a soybean crop.

The bacteria persist in the soil for several years. In fields where soybeans are being grown for the first time in a number of years or where a previous soybean crop had few or no nodules on the roots, bacteria should be added to the seed. *Rhizobia* can be purchased from grain or seed dealers as "soybean inoculant", which is usually available in powder or granular form. Since *Rhizobia* are apt to be killed by heat, the inoculant should be stored under cool or refrigerated conditions until used.

Inoculation with the powder is simple and can be carried out in the field at planting time. As you fill the seed boxes, sprinkle the black inoculant powder over the seed and mix it with your hands. If liberal amounts of the inoculant are applied it generally sticks to the seed quite well. Add the inoculant within half an hour of seeding or the bacteria may dry out and die. Inoculant can also be applied as a

Fig. 3. Inoculation with *Rhizobia* has resulted in the abundant formation of nodules on this root system.

slurry by adding a small amount of water with the powder. If a fungicide-insecticide treatment has already been applied to the seed, use the inoculant dry in preference to a slurry. For practical reasons do not apply fungicide-insecticide treatment and inoculant together in one operation in the seed box.

Granular inoculant contains large numbers of viable *Rhizobia*. The granules are more resistant to drying out than the powder. Also, granules permit the application of very high rates of bacteria with the seed when soybeans are being planted in a field for the first time. Granular inoculant should be applied in the furrow with the seed. With planters, use a modified granular insecticide-herbicide applicator. With drills, either use the fertilizer hopper (if fertilizer is not being applied) or mix the granules with the soybeans in the seed hopper. Usual application rates for new fields will be about 20 kg/ha for 17 cm rows and 7 kg/ha for 60 cm rows. Other methods that do not place the inoculant with the seed, such as broadcast application, would require a higher rate.

Time, rate, and depth of seeding

Begin planting full-season varieties in May when the soil temperature at noon is 14-16°C at a depth of 2.5-5 cm, the soil conditions are suitable for the necessary tillage operation, and there is a low risk of frost after emergence. These conditions will be met in most areas between May 10 and May 31. Where the usual growing season is about 95 days do not plant after May 31 because there will not be enough time for the crop to mature. When wet soil conditions delay planting in southwestern Ontario, which has a fairly long growing season, June planting can be successful.

Seeding rates can be varied considerably without affecting yield. Seeding rate can be increased as row spacing is narrowed, but too high a rate adds unnecessarily to production costs and may increase lodging. Too low a seeding rate may result in poor emergence through crusted soils, may not allow for the expected 10% loss of seedlings each time the soybeans are rotary hoed, and may cause the plants to pod close to the ground. Recommended seeding rates are generally 50-100 kg/ha depending on the row width and variety being used. In 50-60 cm rows you should have 18-24 plants per metre of row at maturity. Because the size of seed can vary with the variety and the year of production, the best way to obtain an optimum stand is to calibrate the planter or drill using the seed to be sown and driving at the speed that will be used. Plant at a reasonable speed (4-5 km/h) to obtain accurate and uniform seeding.

To ensure good germination and emergence, plant soybean seed just deep enough (2.5-5 cm) to be in moist soil. Do not plant any deeper than necessary. If the soil is dry, do not plant deeper than 5 cm; it is usually better to wait for rain than to plant too deep.

Row width

Choose the narrowest row width that the available equipment can handle. To obtain maximum yields for a variety, the crop should have filled in between the

rows by the bean-formation stage. Under cultivated conditions, soybeans generally give a higher yield in 50–60 cm rows than in 90–100 cm rows. With effective chemical weed control, drilled plantings in row widths less than 50 cm may give higher yields than cultivated rows. This is especially true in areas with a growing season of 95–105 days, for example the southern prairies and very late plantings in southwestern Ontario.

Equipment

Corn–soybean planters, grain drills with certain spouts plugged to give the desired row width, and sugar beet planters are used for planting in rows that can be cultivated. Grain drills are used for drilled plantings. Attention should be given to the adjustment and control of planting depth on the equipment being used.

To help emergence of the seedlings, a rotary hoe is an effective piece of equipment for breaking soil crust. It should be pulled at a fast speed (13–19 km/h). The use of a rotary hoe will not seriously reduce the effectiveness of most preemergence and preplant herbicides.

CONTROLLING WEEDS

Cultural methods

The most effective implements for destroying young weeds in soybeans up to 15 cm in height are the rotary hoe, the spike-tooth harrow, and the finger weeder. You will obtain best weed control when the weeds appear as white threads just below the surface of the soil. After the soybeans emerge, it is best to use the implements when the young crop is slightly wilted and less likely to be injured. You should keep the implements free of trash.

After the soybeans are 13–15 cm in height, use a row cultivator to cultivate 3–4 cm deep, fairly close to the plants but without ridging up soil around them, because this would make combining more difficult. As growth continues, the roots spread out rapidly; therefore cultivate shallower and farther from the plants so that you do not cut off too many roots. Cultivate as often as is necessary to destroy the weeds. Cultivation is not advisable after the plants are about 60 cm high; by this time foliage should have nearly filled the rows, providing shade to deter the growth of new weeds.

Chemical methods

Chemicals (herbicides) are used to control weeds in soybeans. A single herbicide may be applied, or two or more herbicides may be used together or in split applications to broaden the range of weed control.

Some chemicals are suitable for use on clay soils, some are better for sandy soils, and others are better for soils high in organic matter. Some herbicides are effective for controlling annual grasses, some are suitable for controlling annual broad-leaved weeds, and others may control certain annual grasses and broad-leaved weeds. Certain herbicides are used for perennial weed control.

Fig. 4. A field of soybeans at midseason.

The time and method of application vary with the herbicide. Some herbicides are applied before planting and are incorporated into the soil by disking or by cultivating with an S-tine cultivator going fast enough to mix them well into the top 10 cm of soil. Some are applied before emergence, and others are applied after emergence. Under certain conditions, chemicals may cause temporary injury to young soybeans, but if recommended rates are used the plants recover without loss of yield. Some varieties cannot tolerate certain herbicides, so you should check the label on the chemical.

Because many chemicals are available for weed control in soybeans it is not practical to include detailed recommendations in this publication. For the most up-to-date information consult the annual publication of your provincial weed committee, available from your local agricultural representative or research station.

The most economical weed control in soybeans is usually obtained through the use of herbicides in conjunction with certain cultural practices. For example, preemergence herbicides may be applied in a band over the row at planting followed by cultivation to control weeds between the rows. Since the most effective and most economical program varies from farm to farm, select the combination most suitable for your farm, or perhaps for certain fields.

DISEASES

Several common diseases attack soybeans in Canada. With the use of resistant or tolerant varieties and good management practices, yield loss from disease is generally not appreciable.

Seed decay

Fungi in the soil or on the seed may rot the seed if vitality is low and soil conditions are unfavorable for plant growth. Control the decay by treating the seed with a fungicide.

Root and stem rots

Pythium damping-off of seedlings may be a problem in cold wet soils. Symptoms include wet rot of hypocotyls and roots or stunting of the growing point. Control by planting good-quality, treated seed in well-drained soil.

Phytophthora rot kills seedlings and growing plants of soybeans, particularly on heavy clay soils, and reduces overall yield. Control the rot by planting tolerant or resistant varieties and by using management practices that reduce soil compaction and waterlogging and that result in good soil tilth. However, in fields where the disease has been a severe problem, use a recommended fungicide if one is available.

Rhizoctonia root rot kills seedlings and growing plants. The underground stem becomes reddish brown. Usually several adjacent plants in a row are killed, but the total incidence in a field is rarely high. There is no control at present.

Leaf diseases

Bacterial blight causes small (3 mm) brown spots on the leaves. The leaves may become torn and ragged because they are weakened at the brown spots. This is a very common disease, but its incidence is reduced by hot weather. At present there is no control.

Downy mildew causes large (6–12 mm) light green areas on the upper surface of leaves, which subsequently become brown; the under surfaces of leaves in these areas have a growth of gray mold. Some varieties are more resistant to this disease than others and will provide some control.

Stem diseases

Stem canker kills plants from early bean-formation to maturity. Symptoms include large reddish brown dead areas on the stems. Some varieties are fairly tolerant of this disease and will provide some control.

Brown stem rot can also kill plants during the same period. You can detect infected plants by splitting the lower stem; the center will be brown, especially at the nodes. When this disease is a problem, rotate with other crops and exclude legumes for 2 years.

Seed diseases

Frequent rainfall and high humidity during the period before and after maturity will increase the percentage of moldy seeds. Germination and vigor may be

adversely affected. A number of different fungi may be involved. Diaporthe mold is often prevalent; it is more severe where soil potassium is low. Crop rotation and adequate potassium in the soil may reduce mold problems.

Purple stain may occur but is not a major problem in Canada. Downy mildew spores may form an encrustation on the seed coat. Seeds may be discolored (mottled) with brown or black pigments in plants infected with soybean mosaic virus. These problems have not been serious enough in Canada to require control.

INSECT PESTS

Soybeans are seldom seriously damaged by insect pests. Seed maggots and wireworms may damage the emerging crop if the seed was not treated with insecticides. The maggots feed on the planted seed, which may not germinate if damaged. If the seed does germinate, the seedlings will die if the maggots burrow up into the stems. The wireworms feed on planted seed and young seedlings. Damage may occur even after seedling emergence.

In some years the green cloverworm (looper) feeds on the soybean foliage during midseason, causing holes in the leaves. Shake the worms from the plants onto paper to count them. If 20 or more worms are found per metre of row, prevent decreased yield by spraying according to local recommendations.

The Mexican bean beetle might require spray control in areas where the beetle occurs on field and snap beans. Leafhoppers, which are pests on field beans, do not seriously damage soybeans because pubescence (hairs) protects the leaves.

If grasshoppers become a problem, spray outer rows of the field with a recommended insecticide. To reduce grasshopper populations maintain weed-free headlands and fencerows.

HARVESTING

The mature standing crop of soybeans is harvested without swathing. An ordinary grain combine performs the harvest job reasonably well if it is adjusted to suit the soybean crop. The combine operator's manual gives the proper settings for concaves, cylinders, fans, and screens to do a good job of harvesting. A number of combine header attachments and modifications are available, such as floating cutter bars and automatic height control, that will reduce harvesting losses.

Run the sickle as close to the ground as possible to reduce the number of pods left on the stubble and those cut by the knife. To do this, use a slow ground speed for the combine. Adjust the reel speed so that the tips are traveling no faster than one and a quarter times the ground speed, and keep the reel operating ahead of the cutter bar and just low enough to guide the plants into the combine. Pod loss will be low and few plants will become entangled in the reel.

STORAGE

If the moisture content is 13% or less, soybeans may be stored in dry bins similar to those used for other grains. They can also be stored in commercial bins

Fig. 5. A field of ripe soybeans in which the upright nonlodged plants will be easy to combine with a low harvest loss.

sold for general grain storage. Soybeans that contain 14% or more moisture when combined should be dried if they are going to be stored. The maximum drying temperature is 49–60°C except for seed soybeans, when the temperature should not exceed 43°C.

When large quantities of soybeans are stored for long periods or during warm weather, aerate them even if they are low in moisture. If the beans begin to warm up or go moldy, they need aeration or they will turn rancid, discolor, and drop in grade. To make aeration effective, remove broken seeds, weed seeds, and plant debris before storing the soybeans in a bin.

PRODUCING SEED SOYBEANS

The soybean is a self-pollinated plant that breeds true unless outcrossing or mixing occurs. The pollen produced in the bud contacts the stigma, bringing about fertilization by the time the flower is fully open. Occasionally, if two varieties are grown near each other, bees may carry pollen from one variety to another, resulting

in an outcross. Care should also be taken not to mix varieties when planting, combining, storing, and cleaning seed. For regulations on isolation and other requirements for producing pedigreed seed soybeans, read the *Canadian Seed Growers' Association Circular No. 6,* obtainable from the Association in Ottawa, or consult your local agricultural representative. Pedigreed seed soybeans are now grown in Ontario, Quebec, and Manitoba.

MARKETING

In areas where soybeans are an established cash crop, they are generally marketed through local dealers for eventual use by processors. Some of the crop may be exported for use in specialty foods. Marketing information for Ontario can be obtained from the Ontario Soya-Bean Growers' Marketing Board, Box 1199, Chatham, Ont.

If a grower is some distance from a processing plant or if the price of protein is high relative to that of oil, whole soybeans may be used on the farm or sold as a protein supplement for livestock. Soybeans in limited amounts may be fed raw to ruminants such as dairy cows. Nonruminants such as swine and poultry are unable to make efficient use of the protein in unprocessed beans; the antinutritional factor (trypsin inhibitor) in the beans must first be deactivated by heating them. Various machines are available for this purpose. Your agricultural representative can supply you with current information on the preparation and use of soybeans as feed for swine and poultry, and for cattle and sheep.

SOYBEAN RESEARCH BY AGRICULTURE CANADA

The aim of soybean research in the Department is to develop varieties and management practices that will result in a higher yield of good-quality soybeans with high oil and protein content.

Soybean breeding and selection work is carried out at a number of research stations. In addition, researchers conduct yield tests in cooperation with provincial and USDA soybean workers.

Management studies are being conducted to determine the best practices for use in tilling, fertilizing, and managing the soil and for use in planting, growing, and harvesting the crop. Chemical and cultural methods of weed control are being evaluated.

The physiology of the soybean plant is being studied to increase understanding of how it grows, develops, and produces seed. Diseases are also being studied and resistance is being incorporated into new varieties. Studies of inheritance are being made to obtain genetic information for use in breeding programs.

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